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Sensitivity Analysis by GeoLog Software for Determination of Water Saturation in Shaly Zones in Well B

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ABSTRACT

The results of well logging is influenced extremely and affected by production properties of reservoir, as well.

In this Study in formation-5, water saturation results that obtained from determine method in comparison with multimine method is more accurate and consistent with core data. In formation-5, dual water determines method and Indonesia multimine method are consistent with core data. In formation-6, water saturation obtained from multimine approach in comparison with core test, Indonesia approach has confirmed. In two formation water saturation obtained from Indonesia determine method, in comparison with other methods, is more consistent with the Indonesia multimine method.

Petrophysical evaluation generally fall is into two Deterministic Petrophysics and Probabilistic Petrophisics. Deterministic Petrophysics Method is older and calculates step by step the parameters of porosity, lithology and water saturation. How to create a diagram of the cores in the laboratory, allowing the destruction of clay minerals during the preparation of charts and measurement errors can be factors of increasing or decreasing the porosity of the core in compared to Geolog software.

Keywords: Sensitivity, X-ray diffraction, Cross plot, Water saturation, Shaly Zones.

INTRODUCTION

Petrophysical evaluation generally fall is into two Deterministic Petrophysics and Probabilistic Petrophisics. Deterministic Petrophysics Method is older and calculates step by step the parameters of porosity, lithology and water saturation. From the disadvantages of this

method are the use of a limited number of logs and random errors of this logs are high. But Probabilistic Petrophisics method based on probability and statistics, and offers statistical solutions. In this method all of available logs used simultaneous, and therefore it has less random errors. Therefore, the optimal evaluation with probabilistic petrophisics method is done by Geolog software (Tadini, 2008).

The results of these kinds of studies are used for modeling of reservoir as relevant data layers. For this reason, many efforts have been made to ensure accurate estimation of shale volume, porosity, water saturation and mineralogical composition obtained. Determination of lithology type, shale volume (Vsh), the total porosity (PHIT), effective porosity (PHIE) and water saturation (Sw) are important parameters that must be determined in petrophysical evaluation to infer quality of the reservoir formation (Hearst *et al*., 2000).

MATERIAL AND METHODS

1. Collecting raw data and ancillary data for the well-studied and split suitable software for computing different petrophysical parameters by both deterministic and probabilistic methods (Geolog).
2. Learning methods Geolog by software (Geolog, Ver.6.7.1), convert raw digital data from a well-to-well to suitable format of Geolog software and applying different corrections on the digitized data.
3. X-ray diffraction experiments (XRD) and cation exchange capacity (CEC).
4. Determine the dominant clay minerals in the formation of cross plots (Cross plot) and comparing with the results of XRD.
5. Petrophysical calculations on corrected data using two methods: Determine and Multimine and the impact of the result of XRD and CEC experiments in calculations and gaining different calculated petrophysical parameters by Geolog software.
6. Comparison of the results of water saturation gaining from Determine and Multimine method and the results from core analysis.

The experiments were carried out:

1. Determination of electrical resistivity formation factor (FRF) in the well-B:

Diagram of core taken at the beginning of the experiment and after washing and drying, the analysis is computed. Then the sample is saturated with salt water with the same salinity of formation water of reservoir. In the next step the electrical resistivity of water (Rw) and the water-saturated sample resistance (Ro) is calculated. Plots taken from cores well-B and petrophysical parameters and quantification of m and a, respectively, for 17 samples in Table 1 and Figure 1 is given.

Table1. Figures taken from the cores with petrophysical parameters obtained from well-B

Sample number	Depth (m)	Permeability (md)	Porosity (percent)	Formation Resistivity Factor (FRF)	Cementation factor (m)
S_3	50.2828	001.0<	1	2795	72.1
S_4	20.2829	161.0	8.1	693	63.1
S_5	53.2831	307.0	3.7	105	78.1
S_6	50.2832	001.0<	4.0	1541	33.1
S_7	91.2832	022.0	4.13	8.47	92.1
S_8	51.2833	007.0	9.5	189	85.1
S_{10}	30.2840	635.1	9.6	148	87.1
S_{11}	73.2840	9.7	7.14	5.43	97.1
S_{12}	71.2841	6.63	8.24	8.16	02.2
S_{13}	35.2845	001.0<	2.1	1805	70.1
S_{14}	22.2848	001.0	7.3	543	91.1
S_{15}	12.2849	028.0	8.5	435	13.2
S_{16}	45.2855	098.0	3.5	231	85.1
S_{17}	12.2856	009.0	5.7	128	87.1
S_{18}	27.2860	001.0<	3.0	10174	59.1
S_{19}	2861	001.0<	5.1	880	61.1
S_{20}	27.2864	001.0<	4.0	1959	37.1

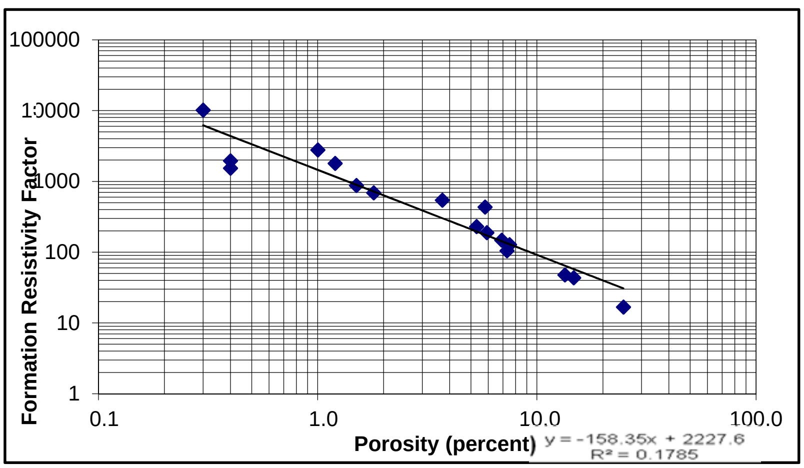

Figure1. Electrical resistivity formation factor versus porosity for determining m and a

2. Testing to determine the specific electrical resistance index (RI) and saturation index (n):

Electrical resistivity index (IR) is determination of the amount of electrical resistivity of the formation when water and hydrocarbons be available in formation. The purpose of this test is determination of formation saturation index (n). In calculation of saturation index, first

washing and drying of test sample should be done and then porosity and permeability calculated. Second, samples under reservoir conditions gradually saturated by oil or mercury.

Then, during testing, electrical resistivity measured, and it continues until the sample saturated by mercury or hydrocarbon. Permeability, porosity, electrical resistivity formation factor, brine saturation, electrical resistivity index and saturation index is given In Table 2 for example for figure S_3, in 2828.5 meters depth. In figure 2 curve of the electrical resistivity versus the degree of saturation in the logarithmic chart for figure S3 is shown to determine the saturation index well- B.

Table2. Petrophysical parameters of Figure S3

Depth (m)	Permeability (md)	Porosity (percent)	Formation Resistivity Factor (FRF)	Salinity	Electrical resistivity index	Saturation Index (n)
50.2828	001.0<	1	2795	1	1	91.1
				969.0	06.1	
				877.0	25.1	
				847.0	33.1	
				816.0	46.1	
				755.0	76.1	
				724.0	87.1	
				693.0	01.2	

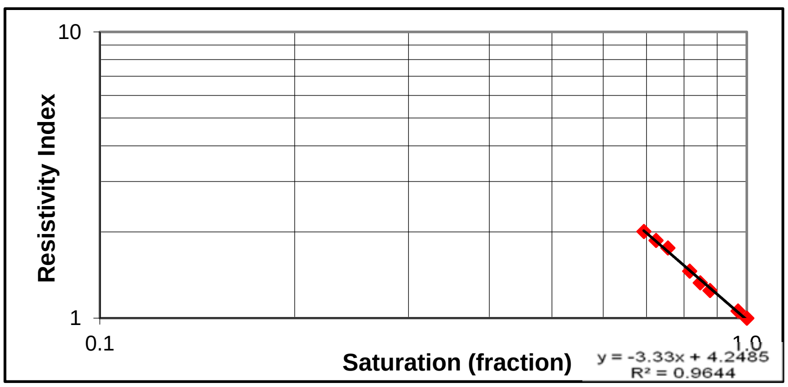

Figure2. Electrical resistivity versus the degree of saturation in the logarithmic chart to determine the saturation index well- B

3. Tests of determining the cation exchange capacity (CEC), clay content, cation exchange (QV) and XRD analysis:

Cation exchange capacity (CEC) makes an important factor in correcting petrophysical parameters and used to calculate the amount of water saturation and determine the volume of hydrocarbons. While most minerals are almost electrically resistant, but clay minerals can act as an extra carriers charge. If we have the CEC of formation, so we can correct

the water saturation calculated. CEC of formation is assumed that is a linear combination of the weights percent of each of the clay minerals in the formation. The best method for calculation of CEC in laboratory situation is preparation of dissolved of clay minerals and determining their CEC by methylene blue that is the most common method used to calculate CEC sub-samples from different depths of the shale layers also. For this purpose, various laboratory methods were used to select the most appropriate method of calculating the CEC. Samples that have graphic well log, petrophysical logs and reports of well lithology, were tested by CEC and XRD. To calibrate the spectrophotometer, we used pure clay sample. Due to the purity of this soil (lightest clay) calibration of the instrument is complete confidence. CEC calculated in shaly reservoirs, reservoir will not only determine the type of clay, but by calculating the amount of clay, cation exchange (Q_v) can be saturated with water relations are based on two-layer model, also used (in two-layer models layer of Q_v is used). Wet chemistry method usually is the best method that used to calculate CEC for soil studies. In this method the sample after washing and drying, is saturated by NaCL solution and then at a certain temperature, dissolved or soluble barium NH^{+4} instead of Na element used and specifies the amount of CEC sample is tested. CEC unit usually reported meqs / 100gr. The XRD analysis for the preparation of samples, the sample must be a maximum of 60 micron sieve. After removal of unwanted materials like carbon tests of acetic acid treatment, samples were washed, dried and weighed and dumped in a graduated cylinder. Sample volume is raised to one liter with distilled water. After complete mixing with a mixer, the samples for 7 hours at 22 centigrade degree are in static situation. Then 200 ml of the upper part removed with a pipette and throw it to the glass. Fine particles in solution are deposited using a centrifugal machine. Samples smaller than 2 microns, dried and then weighed to identify clay minerals are studied by XRD. Then all of the samples in ethylene glycol bath at 60 centigrade degree for 16 hours heated and re-tested by XRD. In the next step these samples are in 300 centigrade degree one time and the other time in 550 centigrade degree and for 2 hours heated and after each step they are subjected to XRD analysis. X-ray tube is of the type Cu and 1.5401 angstrom (A°) is the wavelength. Identification of minerals was performed using standard peak length for montmorillonite is 5 to 15 A°, Vermiculite is 14 to 14.5 A°, Chlorite is 14.2 A°, Kaolinite is 7.1 to 7.5 A°, Quartz is 26.4 A° and Illite is 9.9 to 10.7 used. In Table 3 XRD results of the CEC and the formation of 5 and 6 of well B are shown.

Table3. Results of CEC and XRD in formations 5 and 6

The dominant mineral in the XRD	Description of Sample	CEC (meq/100gr)	Depth of sample (meter of driller)	Core/ drilling Retail	Formation name	well	Formation number
Illite	core	385.9	5.2824	core	3- Upper Dalan	B	5
Illite	core	49.8	2855				6

Comparing the results with the XRD diagrams of the formations cross 5 and 6:

1. Formation 5, 3- upper Dalan:

This core sample was collected from a depth of 2824.5 meters. Table4 shows the percentage of clay minerals. Figures 3, 4, 5 and 6 respectively show the cross plot of potassium versus PEF, the cross plot of the thorium by potassium versus PEF, potassium cross plot versus thorium by the software Geolog and potassium thorium versus cross plot in the range of mineralogical tables are Serra.

Table4. Clay minerals percentage that gained from XRF experiment for sample of formation 5

Clay minerals	Percent
Illite	69.57
Chlorite	07.23
Montmorillonite	53.11
Vermiculite	69.7

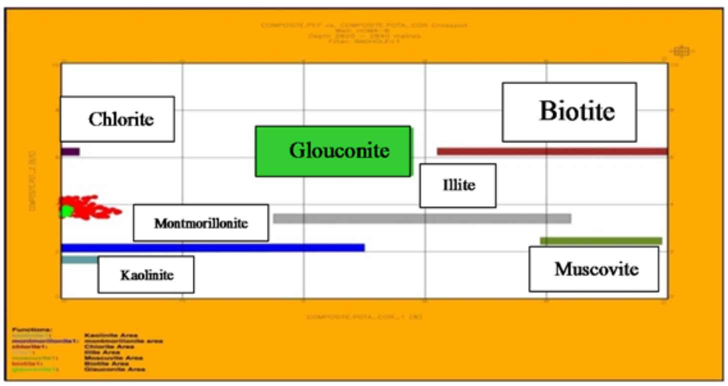

Fig3. Cross plot of potassium versus PED for sample of formation 5

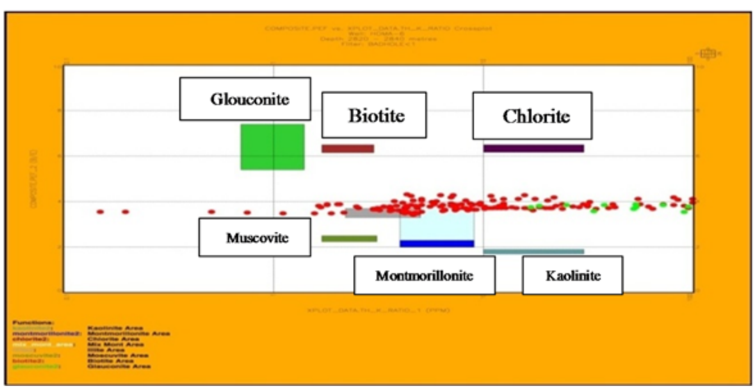

Fig4. Cross plot of the thorium by potassium versus PEF for sample of formation 5

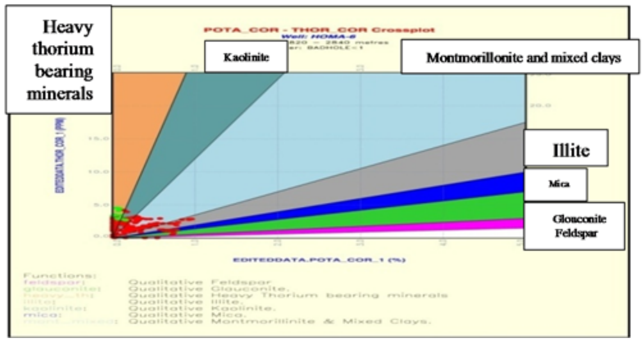

Fig5. Potassium cross plot versus thorium for sample of formation 5

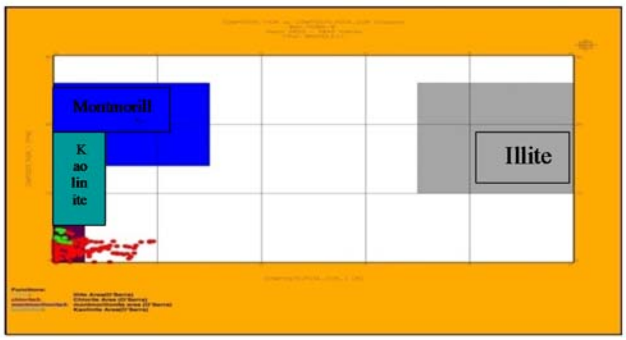

Fig6. Potassium versus thorium cross plot in the range of Serra's mineralogical tables for sample of formation 5.

Illite is the dominant clay minerals that obtained from XRD experiments of formation 5. Cross plots of potassium versus PEF and thorium by potassium versus PEF presents no information about clay minerals. Cross plot of potassium versus thorium shows illite and mixture of clay minerals as the dominate clay. Cross plot potassium versus thorium according to the table in terms of mineralogy of Serra mineral chlorite is the dominant mineral.

2. Formation 6, 3- upper Dalan:

This core sample from a depth of 2857 meters has been sampled. Table 5 shows the percentage of clay minerals. Figures 7, 8 and 9 respectively show the cross plot of potassium versus PEF, the cross plot of thorium by potassium versus PEF and the cross plot of potassium versus thorium.

Table 5. Percent of clay minerals in the formation of 6 from the XRD analysis

Clay minerals	Percent
Illite	55.55
Chlorite	22.22
Kaolinite	51.18
Montmorillonite	7.3

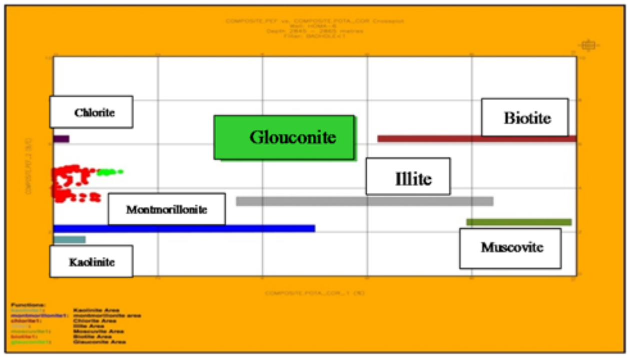

Fig7. Cross plot of potassium versus PEF of formation sample 6

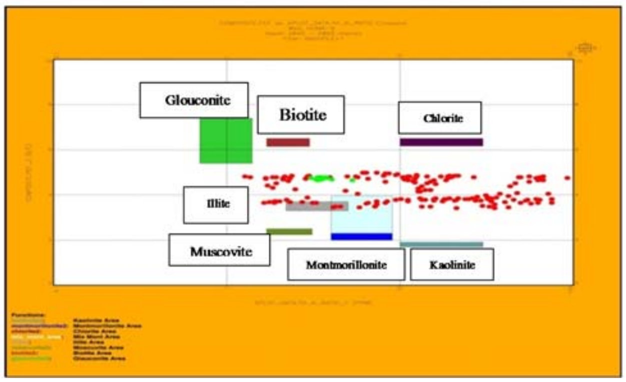

Fig8. Cross plot thorium by potassium versus PEF of formation sample 6

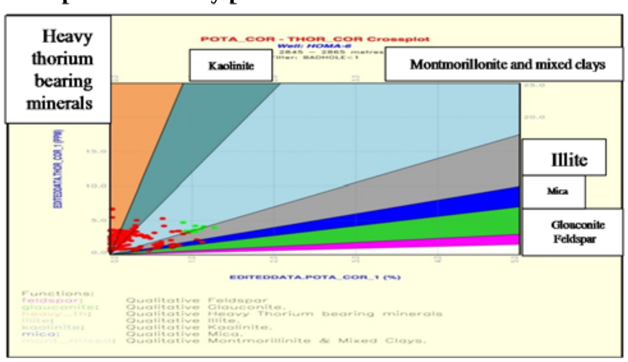

Fig9. Cross plot of thorium versus potassium for formation sample 6

Comparison of different methods petrophysical parameters calculated in formations 5 and 6 by the methods Determine and Multimine:

1. Determine lithology:

Neutron-Density cross plot has the best resolution mineral of the binary diagrams formation (Brock, 1986). When these two graphs are driven at the same time in the well, they

are the most accurate and indirect tool to determine lithology (Clavier, 1984). The cross plot is used to determine the porosity and volume of shale, and is also used to identify lithology and lithology of sandstone; limestone and dolomite are well separated. The transverse cross plot should be careful that if the upper-left corner points cross plot drawn, it can be a sign of gas that must be corrected effect. Therefore, before using this cross plot, you must first correct the effects of shale and hydrocarbons and then plotted data (Schlumberger, 1989). The diagram transverse neutron - density, lithology formation of 5 containing dolomite, limestone and at a slightly shale (Figure 10) and the formation of 6, limestone, dolomite and every bit of shale were detected (Figure 11).

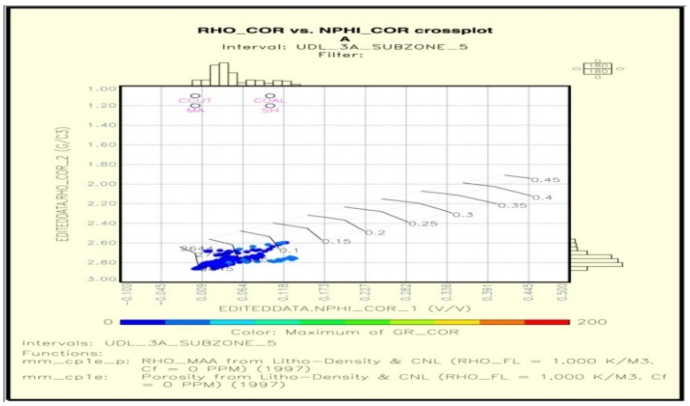

Fig10. Cross plot of neutron- density to identify the lithology of formation 5 (Geolog, Ver.6.7.1).

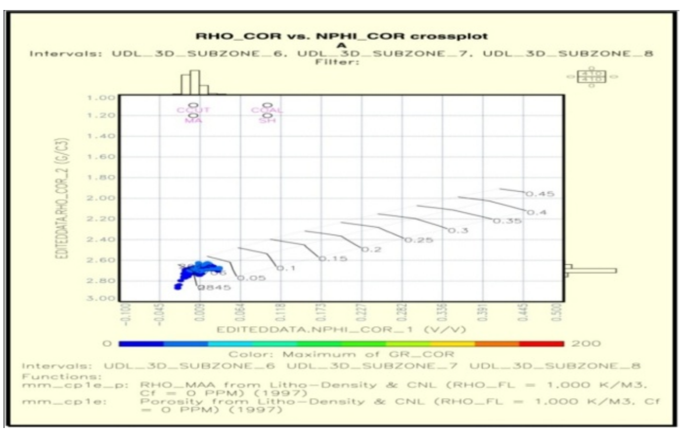

Fig11. Cross plot of neutron-density to detect the lithology of formation 6 (Geolog, Ver.6.7.1).

Volume lithology obtained by the method Determine formations 5 and 6 using three models, Archie, Indonesia and the double water, respectively, in Tables 6, 7 and 8 schematically in column 15 of the figures 12 to 17 are shown.

Table 6. Values obtained by the method of Multimine for lithology of the formation of 5 and 6 using Archie.

Formation (Volume) / Average per cent	Formation 5	Formation 6
Calcite	43.15	84.62
Dolomite	71	22.21
Anhydrite	07.5	8/66
Illite	10.5	12.4
Kaolinite	-	-
Chlorite	-	-

Table 7. Values obtained by the method of Multimine for lithology of the formation of 5 and 6 using Indonesia.

Formation (Volume) / Average per cent	Formation 5	Formation 6
Calcite	16.13	97.61
Dolomite	63.71	05.21
Anhydrite	58.7	26.10
Clay containing water	83.4	93.3

Table 8. The values obtained by the method of Multimine for lithology of the formation of 5 and 6 using dual water

Formation (Volume) / Average per cent	Formation 5	Formation 6
Calcite	38.15	17.64
Dolomite	80.70	17.19
Anhydrite	55.5	8.4
Illite	65.4	31.9
Kaolinite	-	-
Chlorite	-	-

2. Calculation the volume of shale:

In this study the calculation of the volume of shale is done from the log gamma ray (GR) and corrected gamma ray log (CGR). Gamma ray logs indicate the amount of radioactivity in the formation. Because log GR addition to potassium (K), thorium (Th) which is recorded by log CGR, uranium (U) non-clay minerals such as dolomite radioactivity are recorded, so the dolomite formations due to their contains uranium, gamma radiation increases. The gamma ray log is not a good indicator to calculate the volume of shale. The corrected gamma ray (CGR) and using the relation 1 shale volume is estimated (if CGR charts not available, GR graphs used).

$$V_{sh} = \frac{CGR - CGR_{\min}}{CGR_{\max} - CGR_{\min}} \quad (1)$$

In the above relation, CGR from the log, CGR_{min} from the lowest CGR log for each formation and CGR_{max} from the highest value of CGR log in the shaly areas is reading. The CGR_{max} amount is the same for all formations in wells (Brock, 1986). Calculated the average volume of shale wells B by Determine method equal to 2.84 percent and the average volume of shale wells B is calculated using the method Multimine Archie equal to amount 1.59, 1.56 by Indonesia method and dual water model 1.60, respectively gained. The values of the average volume of shale formations by Determine and Multimine methods in formations 5 and 6 in the Table 9 and in the columns 8 and 9 schematically shown in Figures 12 to 17.

Table 9. Amount of average of calculated shale volume by both Determine and Multimine

Formation Parameter (Average percent)	Formation 5	Formation 6
VSH_{av} (Determine)	5.64	4.68
VSH_{av} (Multimine- Archie)	10.5	12.4
VSH_{av} (Multimine- Indonesia)	83.4	93.3
VSH_{av} (Multimine- Dual Water)	48.5	93.3

Shale volume average values obtained from four methods are close together. The results obtained by average volume of shale in formations 5 and 6 that gained from method Determine with Archie model that gained from Multimine method are close together. According to the average values of shale, both formations can be clean component (free from shale) and the average size of the shale formations can be seen as a negative effective factor in changing reservoir properties, but this shows a little amount of shale in studied formations.

3. Porosity calculation:

Porosity is one of the basic parameters of reservoir, because it is indicative of hydrocarbon storage tank (Tiab & Donaldson, 2004). In the deterministic method to calculate the average total porosity (PHIT) and average effective porosity (PHIE), two methods audio (Sonic) and neutron- density (Neutron- Density) is used. In the method Determine, for a transition time (Transit time) sound waves (Δt_{ma}) to estimate porosity using the sonic, the rock matrix that is composed of several lithology, the first method used to calculate the formation of the dominant lithology Δt_{ma}, but more precise method is using the average percent number of lithology of the formation. The main problem is the lack of access to Δt_{ma} of clay minerals In the dry state, so this method is recommended in the case of hydrous minerals (Geolog, Ver.6.7.1). Average values of total porosity and effective porosity obtained from Determine and Multimine methods in formations 5 and 6 are provided schematically in the Table 10, columns 10 and 11 and Figures 12 and 17.

Table 10. Average porosity values calculated according to the two methods Determine and Multimine.

Formation / Parameters (average by percent)	Formation 5	Formation 6
$PHIT_{av}$-S (Determine)	3.35	5.11
$PHIE_{av}$-S (Determine)	2.5	4.41
$PHIT_{av}$-ND (Determine)	2.76	1.23
$PHIE_{av}$-ND (Determine)	1.92	0.52
$PHIT_{av}$ (Multimine- Archie)	3.38	3.13
$PHIE_{av}$ (Multimine- Archie)	3.38	3.13
$PHIT_{av}$ (Multimine- Indonesia)	3.57	3.41
$PHIE_{av}$ (Multimine- Indonesia)	2.79	2.77
$PHIT_{av}$ (Multimine- Dual Water)	3.60	3.38
$PHIE_{av}$ Multimine- Dual Water)	2.76	2.79
Core Porosity	4.26	4.58

Due to some problems we do not have ability to full compliance of core data parameters such as porosity to Geolog software, because doing porosity experiment in environmental conditions and also existing micro-particles in provided figure can cause increasing porosity. How to create a diagram of the cores in the laboratory, allowing the destruction of clay minerals during the preparation of charts and measurement errors can be factors of increasing or decreasing the porosity of the core in compared to Geolog software. According to Table 10 and Figures 12 to 17, the porosity calculated by the method of Indonesia in most formations is more consistent with the core data.

4. Calculation of water saturation:

In this section water saturation is calculated by two methods Determine and Multimine in studied formations by three models Nonlinear Archie, Indonesia and Dual water model and compared with the water saturation obtained from the core. It should be noted that the amount of water saturation that calculated at real is the amount of water saturation can be obtained from the software are done. The amount of water saturation in the laboratory using a two-layer model of water saturation of the CEC and the results obtained that the results obtained in the laboratory using a two-layer water saturation can be a good reference for the actual amount of water saturation in the formation, but because the CEC in the laboratory using the core, measured and calculated through the charts is not possible, use a two-layer model is limited. That's why choosing a model of shale volume models with the lowest error rate is the two-layer model, can be very helpful (Ghasem al-Askari, 2009). Because of Archie model is the most common model in calculation of water saturation in productive formations, in this study additional to calculation of models Indonesia and Dual water, the calculation of Archi model for petrophysical evaluation has been considered to the formations for comparing between different models.

Table 11. Average values calculated effective water saturation according to the methods Determine and Multimine.

Formatio Parameters (average percent)	Formation 5	Formation 6
SWE_{av} - Archie (Determine)	04.64	59.33
SWE_{av} - Indonesia (Determine)	81.63	28.33
SWE_{av} - Dual Water (CEC) (Determine)	04.64	59.33
SWEav - Archie (Multimine)	67.73	19.23
SWEav - Indonesia (Multimine)	88.59	38.25
SWEav - Dual Water (CEC) (Multimine)	74.77	07.23

These volumes schematically are shown in columns 12 and 13 of figures 12 to 17.

According to the values of Table 11 in all formations, effective water saturation (SWE) obtained by using the method Determine by model Indonesia is closer to the average water saturation values obtained by this method is the use of dual water model. Also in all of formations, water saturation obtained Determine method by Archie model containing average values closer to water saturation obtained by using the method Multimine by Indonesia model.

PETROPHYSICAL EVALUATION RESULTS

Formation 5, 3- upper Dalan:

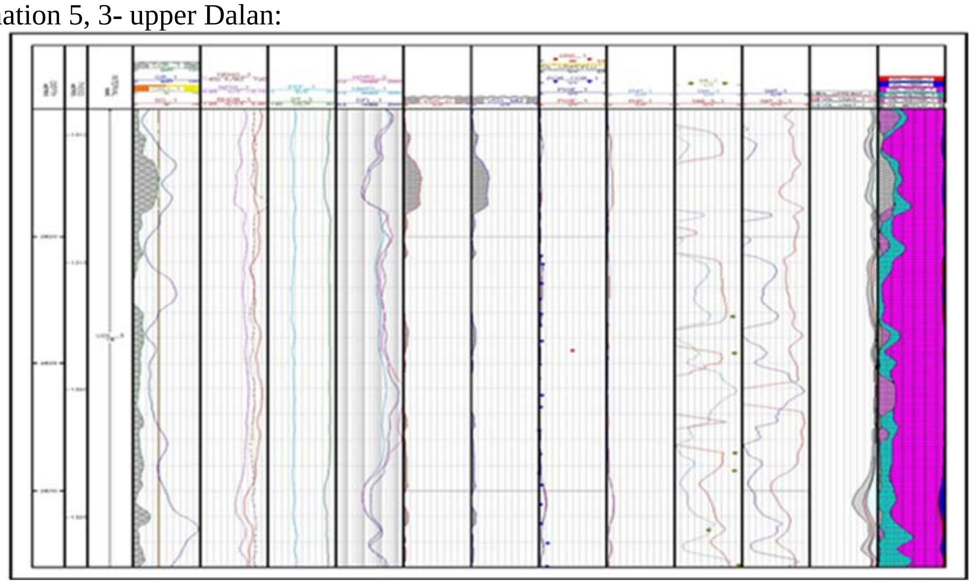

Figure12. Figures and results driven petrophysical evaluation using two methods: Determine and Multimine by Archie model formation 5.

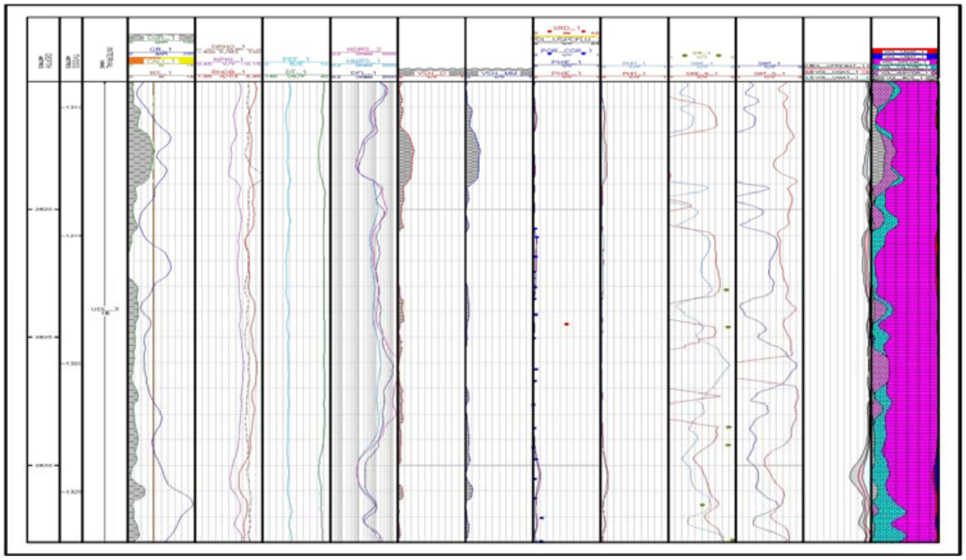

Figure13. Figures and results driven petrophysical evaluation using two methods: Determine and Multimine by Indonesia model formation 5.

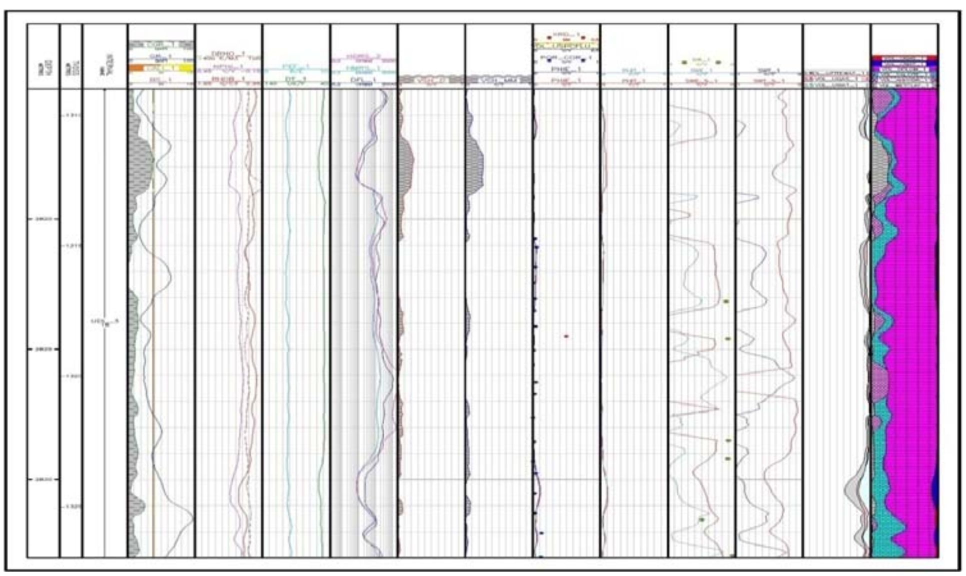

Figure14. Figures and results driven petrophysical evaluation using two methods: Determine and Multimine by Dual water (CEC) model formation 5.

Formation 6, 3- upper Dalan:

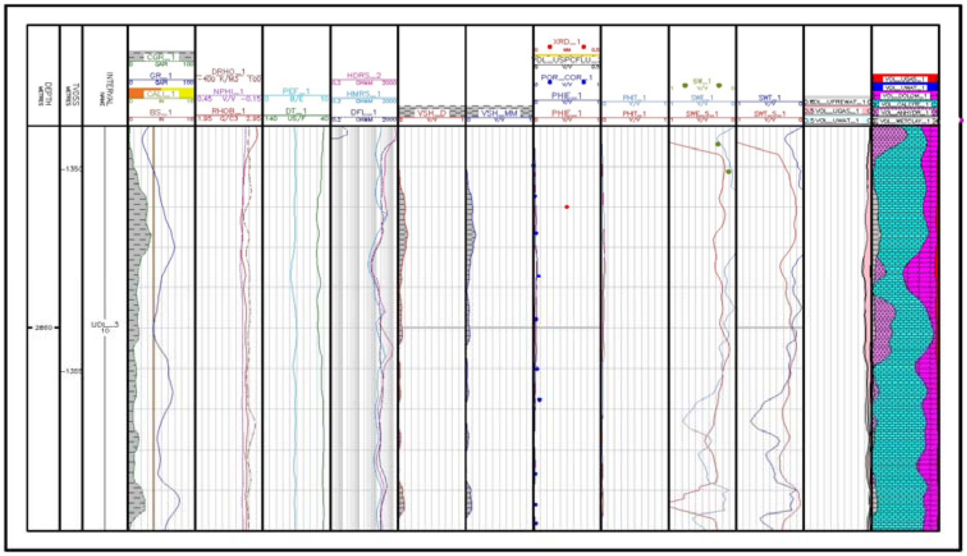

Figure15. Figures and results driven petrophysical evaluation using two methods: Determine and Multimine by Archie model formation 6.

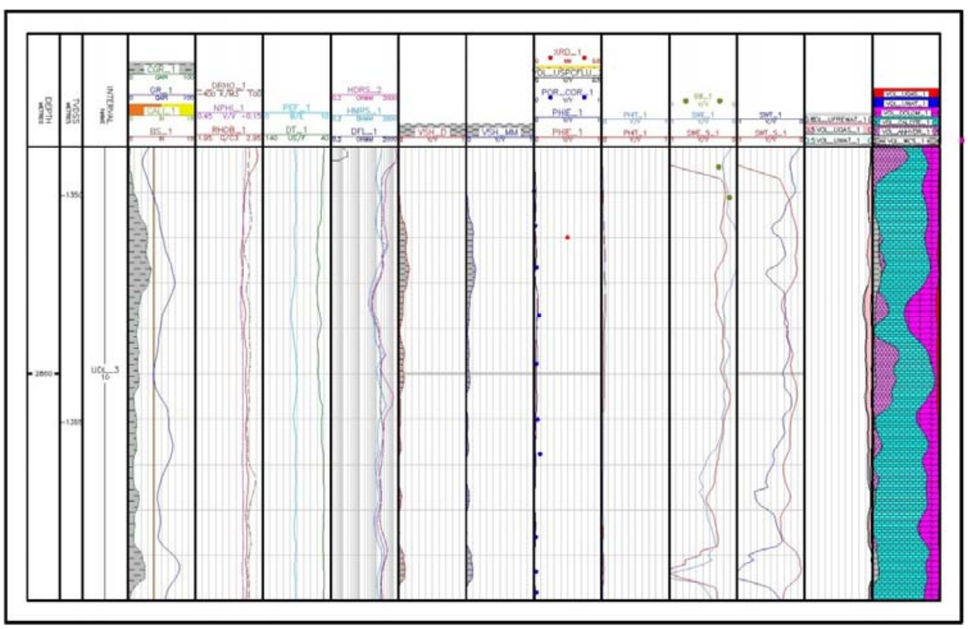

Figure16. Figures and results driven petrophysical evaluation using two methods: Determine and Multimine by Indonesia model formation 6.

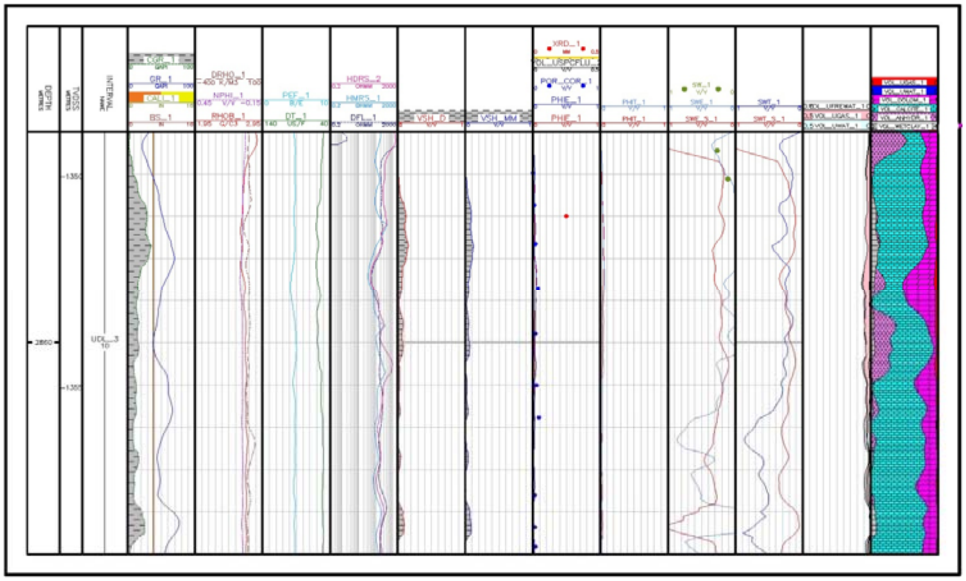

Figure17. Figures and results driven petrophysical evaluation using two methods: Determine and Multimine by Dual water (CEC) model formation 6.

In all Figures 12 and 17, column 1 shows the depth in meters, column 2 represents the true vertical depth in meters. In column 3 name of Intervals, in column 4 corrected gamma rays (CGR), gamma ray (GR), caliper and bit size, in column 5 DRHO, neutron (NPHI) and density (RHOB) logs, in column 6 logs of photoelectric factor (PEF) and sonic (DT), in column 7 electrical resistivity Logs (HDRS, HMRS, DFL), in column 8 shale volume calculated by Determine method, in column 9 shale volume calculated by Multimine method, in column 10 points that sample was taken for XRD analysis, special fluids (USPCFLU), the porosity of the core (POR-COR), effective porosity obtained by the method Multimine (PHIE-1) and effective porosity obtained by the method Determine (PHIE-1), in column 11 total porosity obtained by the method Multimine (PHIT-1) and total porosity obtained by the method of Determine (PHIT-1), in column 12 effective water saturation obtained by the method Multimine (SWE-1), obtained by the method of Determine (SWE-1) and water saturation of the core (SW), column 13 total water saturation obtained by the method Multimine (SWT-1) and total water saturation obtained by the method Determine (SWT-1), column 14 free water saturation volume (VOL-UFRWAT), gas volume (VOL-UGAS) and water volume (VOL-UWAT) and in column 15 Shale volume (VOL-WCS), anhydrite volume (VOL-ANHYDR), calcite volume (VOL-CALCITE), dolomite volume (VOL-DOLOM), water volume (VOL-UWAT), gas volume (VOL-WCS) is obtained.

RESULTS AND CONCLUSIONS

If the parameters Determine method calculated accurately, especially porosity, similar results are obtained with Multimine. In this study using neutron-density cross plot, formation

lithology 5 contains dolomite, limestone and shale intervals in the form of a 6-limestone, dolomite and shale were detected in small distances. Average volume of shale in well B using method Determine is 2.84 percent and Multimine method using models Archie, Indonesia and dual water amounts respectively 1.59, 1.56 and 1.60 respectively. In well B small amounts of shale in the reservoir properties considered as a negative factor and is not important, however, suggest that small amounts of shale Formations is studied. Illite is the dominate clay mineral by XRD experiment and by using cross plot of thorium versus potassium the dominates are Chlorite and Kaolinite and cross plot of thorium versus potassium according to mineralogy table Serra introduce Chlorite as a dominate clay mineral and by using the results of XRD analysis of the dominant clay minerals is Illite and with cross plots Illite and Mica diagnosed as dominate clay minerals. In the Determine method, for the calculation of the transition period, the average percentage in each formation lithology is more accurate than the method of dominant lithology in each formation. And in the case of hydrous minerals are recommended. Data analysis shows that the porosity of the Formations of well B wells are low and do not change much with the low porosity shale volume, porosity is the most effective type. The amounts shale volume, effective porosity and total porosity were calculated on the basis of the results obtained by the method Determine is corresponded with Multimine and also with the core data. This is because of the replacement of exact values of the parameters. In the formation 5, the results of water saturation obtained using the method Determine in comparing with Multimine are more accurate, and this corresponded with the core data. In formation 5 between models Determine and Multimine respectively Dual water and Indonesia models was more consistent with core data. Results of water saturation in formation 6 by Multimine method in comparing with core experiment accepting Indonesia model. In both studied formations, water saturation gained from Indonesia model by Determine method is more consistent with Multimine method (in comparing with Dual water and Archie models). According to the model designed and the results of different models, well studied included carbonate rocks, clay minerals (illite, chlorite and kaolinite), gas and water. Preparation of thin sections of the cores obtained from all formations for the purpose of authenticating the way studies are necessary. Chemical analysis of more samples in order to determine water saturation experiments using cation exchange capacity is necessary. Doing experiment of CEC and XRD is suggested for more samples in order to making CEC log and different lithology logs gained from XRD in studied formations for using XRD in part of Multimine.

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